

A Randomized Trial of the Impact of Amber Versus Blue Glasses

on Sleep Quality, Energy and Mood

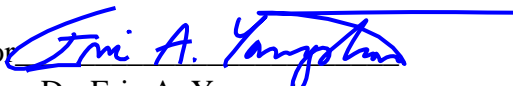
Julia N. Lukacs

University of North Carolina at Chapel Hill

Spring 2015

A thesis presented to the faculty of The University of North Carolina at Chapel Hill in
partial fulfillment of the requirements for the Bachelor of Arts degree with Honors in Psychology.

Advisor


Dr. Eric A. Youngstrom

Acknowledgements

First and foremost, I extend my gratitude to the participants in this study, without whom this research project could not have been completed.

Second, I would like to thank the members of my committee. This thesis was completed with the help and constant support of both my advisor, Dr. Eric A. Youngstrom, and Tate Halverson, my graduate student mentor. I have learned much through this process with their help and would not have come this far without them. I would also like to thank Dr. Barbara Goldman, who understood my ambitions and believed in my ability to write a thesis even before I fully believed in it myself.

I would like to thank the entirety of the MECCA lab. Mian and Steph have been welcoming beyond belief and a joy to be around. I would also especially like to thank Lindsey, Kenny, Yen-Ling, and Uchenna for their constant willingness to jump in where help was needed.

I am very grateful to my friends and family for their help and support throughout the years, and especially this past year. This list includes but is not limited to: my mother, Zsuzsanna, my father, Gabor, my two weird wonderful lovable brothers, Martin and Mihaly, and my dog, Sophia, who always keeps me sane. My friends have also been instrumental in keeping me upbeat and motivated, whether they were pushing me to keep working via the internet, watching favorite movies with me, or playing hard on the soccer field to let off steam.

Finally, I would like to acknowledge the support for this work from the UNC Psychology Department and the Stephenson Award Fund, resources without which this endeavor would have been much more difficult. Thank you again to all for being a part of this transformative opportunity!

Abstract

The connections between sleep and mood disorders have prompted speculation in the field of psychology for some time. The human circadian rhythm, the biological mechanism which has a significant impact on the diurnal highs and lows of both wakefulness and mood, is impacted by a variety of endogenous and exogenous factors. One of the most potent of these factors is light, but it has recently been proven that the absence or presence of blue wavelength light (446-477 nm) has a particularly strong effect. With the use of blue light blocking amber lenses, one may be able to influence and regulate sleep, mood and potentially mental health for the better, especially in individuals for whom these cycles are disrupted.

In a randomized trial, 27 students at the University of North Carolina at Chapel Hill, aged 18-26, wore either control blue or experimental amber lenses for three hours prior to their own calculated average bedtime for 12 days of an 18 day protocol. Participants completed self-report measures of sleep quality, mood, and somatic complaints on a daily basis, and more precise measures of sleep quality every 6 days. The first 6 days when they did not wear glasses were compared to the later 12 days during which they did wear the blue or amber glasses. There was a significant improvement in sleep, energy, and mood when participants wore the amber and blue glasses ($p < .005$), but there was no difference between the two conditions. Future directions could include the use of more objective sleep measures and testing glasses of different colors.

A Randomized Trial of the Impact of Amber Versus Blue Glasses on Sleep Quality, Energy

Sleep is a crucial part of life. However, many individuals experience difficulty sleeping at some point in their lives. Individuals who work overnight shifts, those struggling with sleep disorders, and anyone who has ever flown across multiple time zones or stayed awake all night to finish an important task may notice an evident decline in function, but sleep troubles do more than just make life more difficult in the short term. Circadian clock dysfunction has been shown to impact numerous systems in the body. Links between circadian dysfunction and cancer, diabetes, obesity, impaired memory, and premature birth are only a few of the effects (Zelinski, Deibel, & McDonald, 2014). Sleep also appears to be connected to mood, psychopathology and mental health in general (Harvey, Murray, Chandler, & Soehner, 2011). Sleep disturbances, such as insomnia and hypersomnia, are some of the common symptoms of mood disorders, such as depression, bipolar disorder, and anxiety (American Psychiatric Association, 2013).

This evidence supports the claim that circadian rhythms, the approximately 24 hour cycle of activity in the body that controls energy level, might have an effect on far more than just the sleep-wake cycle. One of the strongest influences on circadian rhythms is light (Zelinski et al., 2014). In particular, exposure to blue-wavelength light may be especially important to sleep because it appears to decrease the production of melatonin, an integral part of the sleep-wake cycle (Kayumov et al., 2005; Lockley, Brainard, & Czeisler, 2003; Sasseville, Paquet, Sevigny, & Hebert, 2006). Researchers have established the connections between mood and sleep, as well as the potential impact of filtering blue wavelength light on both mood and sleep (Burkhart & Phelps, 2009). However, the effects of blue light filters on mood and mental health based on changes in sleep still needs further investigation.

The Circadian System

The sleep-wake cycle in humans is controlled by circadian rhythms. This cycle encompasses more than just wakefulness during the day and sleep in the evenings. In normal individuals, the pattern shows a midday drop in alertness at around 2-4 p.m., and an increase in alertness in the mid to early evening. Alertness is lowest at around 4-6 a.m. (Barion, 2011). The process by which this cycle is kept at approximately 24 hours in length based on environmental cues, like sunlight, is called entrainment (Harvey et al., 2011). Irregular shifts, backwards and forwards, in the 24 hour sleep cycle are referred to respectively as phase delay and phase advancement (Barion, 2011).

The circadian rhythm is controlled by the suprachiasmatic nuclei (SCN) which are a part of the central nervous system (CNS) and housed bilaterally in the anterior hypothalamus. The SCN consist of two parts, a core and a shell that work together to synchronize electrical activity in the brain in a cyclical pattern that is referred to as a circadian oscillation. The electrical patterns are synchronized based on endogenous and environmental factors. The core of the SCN has no endogenous rhythmic pattern, and without environmental input, there would be no discernible cyclical pattern to the electrical activity. The shell, in contrast, is controlled by mostly endogenous signals, and serves to stabilize the rhythms by connecting the SCN, the hypothalamic nuclei, and the CNS (Zelinski et al., 2014). Input pathways bring information into the SCN and output pathways send the synchronized information to the rest of the body. (McClung, 2011).

Circadian Systems, Sleep, and Mood

The approximately 24 hour patterns that are created through the synchronization of the SCN inform diurnal cycles in the human body, such as sleep-wake patterns (Zelinski et al., 2014). Individuals with sleep disorders may have altered synchronization of rhythms, hence the

classification for one category of sleep disorders, Circadian Rhythm Sleep Disorders (Barion, 2011).

Mood has also independently been investigated for evidence of a diurnal cycle influenced by circadian rhythms via the SCN. Subjective self-reports of mood reach their most negative when core body temperature is at its lowest, in synchrony with a circadian cycle (Monk, Buysse, Reynolds, Jarrett, & Kupfer, 1992). Some research shows the potential for a variety of gene-environment interactions. Studies have shown that mice with alterations in specific Circadian Locomotor Output Cycles Kaput genes, often referenced as clock genes, display symptoms similar to those of bipolar disorder, and the use of lithium alleviates those symptoms (Roybal et al., 2007). Two neurotransmitters implicated in mood disorders, serotonin (5-HT) and dopamine (DA), have been found to interact with the SCN and circadian rhythms (Kennaway, Moyer, Voultsios, & Varcoe, 2001; Yan, Bobula, Svenningsson, Greengard, & Silver, 2006). As a result, some researchers hypothesize that mood, as manifested in psychiatric disorders, and circadian systems may be connected by dopamine and serotonin pathways (Harvey et al., 2011).

The sleep-wake cycle is also connected to mood. Disturbances in sleep have been associated with increased amygdala activation, increased negative affect in the face of goal thwarting, and decreased positive affect in the face of goal enhancing (Yoo, Gujar, Hu, Jolesz, & Walker, 2007; Zohar, Tzischinsky, Epstein, & Lavie, 2005). Multiple studies find significant comorbidity of sleep disorders and various clinical disorders. Epidemiological studies show comorbidity of hypersomnia and mood disorders to be anywhere from 9% to 76%, depending on age (Kaplan & Harvey, 2009), while the comorbidity of insomnia and mood disorders is 50-70% (Van Mill, Hoogendijk, Vogelzangs, van Dyck, & Penninx, 2010). The variations in sleep phase or severity of sleep disorder symptoms may have significance at the individual level. For

example, a significant positive relationship has been found between the degree of sleep phase misalignment and symptom severity in patients with major depressive disorder (Emens, Lewy, Kinzie, Arntz, & Rough, 2009).

Light as a Zeitgeber and Light as an Intervention

Light is one of the strongest environmental factors influencing circadian rhythms and sleep. It is also the factor of chief interest in this study. Visual input reaches photoreceptive retinal ganglion cells, which then express melanopsin. The melanopsin message passes through the retinohypothalamic tract to reach the hypothalamus and eventually, the SCN (Zelinski et al., 2014). The SCN directs the pineal gland to produce melatonin, which then impacts alertness. Light is considered to be a *zeitgeber*, along with other physiological signals such as blood pressure, insulin, and sex hormones. The German word *zeitgeber* directly translates to “time giver” and refers to a factor that influences an individual’s internal clock.

Sleep disorders reflect the relationship between light, sleep, and circadian rhythm phase changes. One type of Circadian Rhythm Sleep Disorder, Non-Entrained Sleep Disorder (Free Running Type) involves increasingly delayed circadian rhythms, and is rare in sighted individuals, but common in blind individuals. This is a significant reason to consider the aforementioned role of photoreceptor retinal ganglion cells as environmental input (Barion, 2011).

This evidence of the connections between the SCN and mood, and the SCN and sleep, support the argument that improving sleep may also improve mood. As a result of these close relationships, light therapy has been targeted as a treatment for sleep disorders and mood disorders. For example, Seasonal Affective Disorder, or SAD, appears to be connected to seasonal rod and cone sensitivity in the eyes. As a result, light therapy appears to have a positive

impact on SAD (Lavoie et al., 2009). Meta analyses have found bright light therapy to be effective treatment for non-seasonal depression as well as seasonal depression independently (Even, Schroder, Friedman, & Rouillon, 2008; Golden et al., 2005). For other disorders, such as mania in bipolar disorder, dark therapy may be effective for shorter manic episodes (Barbini et al., 2005). This research provides evidence for the role of light or lack of light as a treatment in mood disorders.

The efficacy of many of these treatments may be influenced by a particular property of light, namely the presence or absence of blue wavelength light. Light most strongly suppresses melatonin at 446-477 nm wavelengths, the blue portion of the visible spectrum (Lockley et al., 2003). One study found that wearing amber (sometimes referred to as orange) lenses, which block the transmission of blue light, led to no significant melatonin suppression in subjects asked to stay awake overnight in a brightly lit laboratory, compared to baseline measures taken overnight in a dim light laboratory setting. The results taken overnight without the blue-blocking lenses in a brightly lit laboratory, in contrast, show that melatonin was significantly suppressed compared to the dim light condition (L. Kayumov et al., 2005).

Another study showed that wearing amber blue blocking lenses during a 60 minute bright light pulse from 1 to 2 am led to no significant change in melatonin suppression, while wearing grey tinted glasses during the 60 minute bright light pulse led to a significant increase in melatonin suppression (Sasseville et al., 2006). Amber lenses, in comparison to yellow lenses, worn over two weeks have also been shown to lead to a significant increase in sleep quality and a significant increase in positive affect on the Positive and Negative Affect Schedule (PANAS) (Watson, Clark, & Tellegen, 1988), a measure frequently used in studying mood disorders, as

compared to one week of baseline measures in a sample of 20 subjects with sleep onset and mid sleep insomnia (Burkhart & Phelps, 2009).

Current Study

These results support the potential of blue-blocking glasses as an intervention for individuals struggling with sleep disorders and mood disorders. The lenses place users into physiological darkness, with regards to their photoreceptors, but do not limit their ability to see well enough to function on an everyday level. For example, individuals with Shift Work Type Sleep Disorder, caused by a shift in circadian rhythm due to work, could theoretically use the glasses during work or while commuting without lowering their abilities to perform tasks, and the glasses could help to sustain melatonin levels and regulate circadian rhythms. The amber lenses could also potentially aid in regulating circadian rhythms in individuals with comorbid mood and sleep disorders, altering both sleep patterns and mood.

However, in order to confirm the potential benefits of blue-blocking glasses, further research is necessary. The PANAS may not be the best measure of affect to use, because many of the items do not pertain to sleep, particularly within the negative affect subset of the schedule. The yellow glasses may not have served as an adequate control, and testing with different color lenses may be beneficial. Yellow lenses block some blue light, potentially leading to physiological changes in the comparison condition that could distort the effect sizes observed. More objective or refined ways of measuring sleep quality would also be beneficial to this area of study. The small sample size in studies to date limits generalizability, and the connection between the glasses, photoreceptors, and circadian rhythms needs further support, even if that is provided in the form of additional research using a similar paradigm.

Therefore, researchers in this study will replicate and refine the work of Burkhart and Phelps (2009) to further elaborate on the direction and scope of this area of research. We hypothesize that the use of blue light blocking amber lenses in the evening prior to sleep could improve sleep quality and mood. Specifically, the researchers hypothesize that those subjects in the blue-blocking amber lens condition will improve significantly in both sleep quality, energy, and positive affect, and decrease in negative affect as compared to their baseline measures, while those subjects wearing blue control lenses will not improve in either measures of sleep quality or measures of positive and negative affect as compared to their baseline measures. Researchers also hypothesize that somatic complaints will decrease in the amber lens condition, while they will not change from baseline in the control blue lens condition.

Methods

Participants

Participants (25 female, 6 male) were recruited for the study through a service organization and through flyers on campus at a large southeastern university. The service organization was contacted to ensure that the experiment could be a viable service opportunity for members, and an ad was posted to the service organization's Facebook page. Flyers were posted around campus. Volunteers indicated interest through email. There were no exclusion criteria for the participants, and all participants who volunteered through the service organization received 40 hours of service credit, while all participants who volunteered through the flyers were entered in a drawing for one of two prizes of \$150 dollars in compensation for their work on the study. Participants could not be eligible for both forms of compensation. Three participants dropped out in between consenting but before starting the study protocol, and after

the study began, one more participant dropped out, leaving 27 participants (21 female, 6 male) who completed the protocol.

Materials

Participants wore glasses with either blue lenses or amber lenses for days 7 through 18 of the 18 day study. The glasses were Uvex Skyper Anti-Fog Safety Glasses in orange (S1933X) and blue (S1932X). Figure 1 shows the light transmittance of each type of glasses. We chose this particular model of glasses because the orange lenses block a large percentage (>99%) of blue light, while the blue lenses let in a majority of the blue light. The researchers asked that the participants place the glasses on three hours prior their own calculated average sleep time (based on their bedtime for 6 days of baseline measures) and not remove them for the remainder of the evening while exposed to light, because any direct or indirect light could interfere with melatonin levels. They were not asked or required to wear the glasses overnight or while asleep. The researchers assessed compliance with this protocol on the basis of “selfies” sent via email and participant self-report of compliance at time of debriefing.

Measures

Participants, in addition to wearing the glasses, completed a sleep diary on paper and a variety of self-report measures online. The sleep diary was completed throughout the day, and the self-report measures were completed as soon as possible after waking up.

Daily sleep diary. The sleep diary is a commonly used measure, recommended by the American Academy of Sleep Medicine (<http://yoursleep.aasmnet.org/pdf/sleepdiary.pdf>). It asks about the time the participant got in bed, went to sleep, woke up, got out of bed, as well as exercise, medicine, alcohol, and caffeine intake during the day. We used a modified version that also assesses sleep quality on a scale of 0 to 5, 0 being “terrible”, and 5 being “excellent” and

energy on a scale of 0 to 5, 0 being “very low, exhausted” to 5 being “excellent energy” for the following day. Finally, the diary also asks participants to note the time they put on the glasses, when applicable (Youngstrom, 2014, December).

Daily emotion ratings. The Positive and Negative Affect Schedule (PANAS) measures mood in two domains, positive and negative emotions. The schedule consists of 20 items, 10 of which are associated with negative affect, and 10 of which are associated with positive affect. Participants rated the items on scale of 1 to 5, 1 being “very slightly or not at all”, and 5 being “extremely”, based on how they felt at the moment. Sample items include the words “nervous”, “upset”, “inspired”, and “excited”. High scores indicate a high level of positive and negative affect respectively. The Cronbach’s coefficients for a daily measure of the PANAS are .90 and .87 for positive affect and negative affect respectively (Watson et al., 1988).

Daily somatic complaints. The von Zerssen Complaint list is a list of 65 items which assess agreement to physiological and psychological complaints on a scale of 0 to 3, 0 being “severely” and 3 being “not at all”. The measure was cut down to 48 items for brevity and clarity. Sample items include “fatigue”, “brooding”, “a feeling of weakness”, “shortness of breath”, and “trembling”. Participants were asked to rate the items based on how they felt at the moment. As a consequence of the reverse scale, a higher score indicates a lower level of complaints (von Zerssen, 1975).

Sleep quality and problems. The Pittsburgh Sleep Quality Index (PSQI)(Buysse, Reynolds, Monk, Berman, & Kupfer, 1989) assesses sleep quality and patterns of sleep in adult populations over a month-long period. For this study, we altered the reference time frame to the past six days. The measure covers seven components, including subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medications,

and daytime dysfunction. It includes both open-ended questions asking about hours of sleep and bedtime, as well as rankings on a scale of 0 to 3, 0 being “not during the past week” and 3 being “three or more times a week.” Sample items include “wake up in the middle of the night or early morning”, “have bad dreams”, and “during the past week, how much of a problem has it been for you to keep up enthusiasm to get things done?” The internal consistency for the PSQI is .83 and the test-retest reliability is .85 (Buysse et al., 1989).

Chronotype: Morningness versus eveningness preference. The Student Morningness-Eveningness Questionnaire (SMEQ)(Koščec, Radošević-Vidaček, & Kostović, 2001) assesses when an individual’s peak alertness is during the day. Individuals receive from 0-2 points for the answers to each question, based on habits over a 24-hour-period. Sample items include both open-ended questions, such as “At what time in the evening do you usually start feeling tired and sleepy?”, and multiple choice queries, such as “If you have to stay awake after your usual bedtime, do you find it difficult?”, with the possible answers of “I always/usually/usually do not/never find it difficult.” A low score indicates a “morning person”, while a high score indicates an “evening person”. The SMEQ has an internal consistency of .77 (Koščec et al., 2001).

Procedure

All individuals who volunteered in response to recruitment effort were invited to participate in the study. Prior to beginning the study, the researchers met with the participants individually to obtain consent and assess baseline measures. Participants provided informed consent, and provided demographic information, including sex, age, race, ethnicity, year in school, and medical history, including any current medications and diagnoses. Participants were also asked if they had any prior knowledge of different colored lenses or glasses improving

sleep, and their answer was recorded. Regardless of their answer, we asked them to refrain from further researching the impact of different colored lenses on sleep for the duration of the study.

In addition, participants received instructions for completing the sleep diaries, the SMEQ, the PANAS, the von Zerssen Complaint List, and the PSQI. Finally, participants completed a baseline SMEQ. Using this information, the researchers randomized the sample for the control (blue lens) or experimental (amber lens) condition, using a matched-subjects design to ensure equal distributions of each sex and morningness/eveningness in each condition. The day before the study began, participants got their pair of glasses, a sleep diary, and an instruction sheet to help them remember what to do each day.

During the first six days, for the baseline measures, participants completed the sleep diary throughout each for Day 1 through Day 6. The researcher sent an email reminder about tasks at 10 a.m. every day, and participants also completed the Von Zerssen Complaint List and the PANAS through Qualtrics in the morning. If they had not completed the survey by 3 p.m., the researcher sent another reminder to them. The participants completed the PSQI for the first time on the final day of the baseline measures (Day 6). On day 6, participants also emailed the researchers a list of the times they went to bed each evening, and the researcher calculated an average sleep time for each participant, which then anchored the period for wearing the glasses to begin at three hours prior to the person's typical bedtime.

For Day 7 through Day 18 participants put the glasses on three hours before the calculated average "go-to-sleep" time, and completed the sleep diary, the von Zerssen Complaint List, and the PANAS daily, in the mornings, through Qualtrics. Participants also emailed a selfie of themselves each night to the researchers to assess compliance, improve engagement, and maintain communication between the researchers and participants. Reminder emails were sent at

10 a.m. and 3 p.m. for the surveys, and at 7 p.m. for wearing the glasses and sending a selfie. On Day 12 and Day 18, participants also completed the PSQI for the second and third time, respectively. Shortly after the final day, participants completed the SMEQ for the second time, and returned the glasses and completed sleep diaries.

At debriefing, the researcher asked participants to share any experiences with the glasses, disclose if they had not worn the glasses any of the days of the study, and to indicate which days they had not worn the glasses, using the sleep diaries. The researchers gave participants a debriefing packet to explain their role in the experiment and aid them in recording the 40 hours in the service learning database, when applicable.

Statistical Analyses

Researchers wanted to test the hypothesis that participants in the amber lenses experimental condition would see more improvements in sleep quality, complaint levels, and mood than participants in the blue lenses control condition. We ran a mixed regression model for all hypotheses (Bolger & Laurenceau, 2013; Raudenbush & Bryk, 2002), with predictors of wearing or not wearing glasses (rating period), lenses color (amber or blue), and the interaction of rating period and lenses color, testing for the outcomes of sleep quality via the PSQI and the sleep diary, and energy, positive affect, negative affect, and complaint levels.

Results

Table 1 reports the distributions of gender, mean age, and mean year in school, for the participants, and for each of the 2 groups (or color of lenses). Table 2 shows the distribution of ethnicity for the participants. Table 3 shows descriptive statistics for Positive Affect (POMP transformed), Negative Affect (POMP transformed), von Zerssen scores, Sleep Quality (from the sleep diary) and Energy (from the sleep diary). Many of the measures used a percent of

maximum possible transformation, also known as POMP (Cohen, Cohen, Aiken, & West, 1999). Exploratory analyses also examined rationally derived PANAS scores focusing on items we expected would be more influenced by sleep changes.

Researchers hypothesized that individuals in the amber glasses condition would have higher positive affect scores and lower negative affect scores when they wore the glasses, and that individuals in the blue glasses condition would experience no change. The individual item descriptive statistics for the Positive Affect (PA) and Negative Affect (NA) in the PANAS showed high internal reliability. Items in the PA Subscale had an internal reliability of .935, while items in the NA Subscale had an internal reliability of .851. The PA Subscale and NA Subscale were correlated at .06 ($p = .233$), showing no significant correlation between the subscales, consistent with prior investigations of current mood state report (Watson et al., 1988).

Mixed regression models tested the color of glasses, wearing glasses or not (rating period), and the interaction of the color and rating period, using PA (POMP) and NA (POMP) as outcome variables. PA (POMP) scores showed only a significant intercept ($b_0 = .36, p < .01$). This meant that when individuals had not been wearing glasses and they were in the blue group, the intercept was significantly different than 0; the lack of significance for the glasses color term indicated that the baseline scores in the orange glasses group were similar. Because the rest of the predictors were not significant, this meant that the slope of PA (POMP) scores did not change based on whether individuals had been wearing glasses or not, what color glasses they had been wearing, or the interaction of what color glasses they had been wearing and whether they were currently wearing them or not.

The second model for Negative Affect (POMP) Scores showed a significant intercept ($b_0 = .15, p < .01$) and a significant value for whether the individual was wearing glasses or not ($b_1 =$

-.05, $p < .01$). This meant that when glasses were blue and the participant was not wearing glasses, the score on NA is significantly different than 0, and that the slope for NA (POMP) Scores differed significantly based on whether or not individuals were wearing glasses or not. The color of the glasses and the interaction of color of glasses and rating period were not significant.

The researchers also hypothesized that von Zerssen scores would increase (complaints would be decreased) in individuals when they wore the orange glasses. Those individuals wearing blue glasses would not see a change. The item by item descriptive statistics for the von Zerssen showed a total internal reliability of $\alpha = .96$. The scores for the von Zerssen were skewed slightly negatively (meaning that scores in general tended to be higher, indicating lower levels of complaints, with a few people showing extremely low scores), but not enough to warrant a transformation, since the level of skewness was still between 3 and -3 – a range where parametric methods tend still to be robust.

The researchers ran a mixed model with color of glasses, whether the individual was wearing the glasses or not (rating period), and the interaction of the color and rating period as predictors, and von Zerssen Score as the outcome variable. The intercept ($b_0 = 170.65$, $p < .01$), and rating period ($b_1 = 6.51$, $p < .01$) were significant. This meant that if glasses color was blue and the individual was not wearing glasses, the intercept was significantly different than 0, and scores on the von Zerssen differed significantly overall when wearing glasses as opposed to not wearing glasses. Color of glasses and the interaction between color of glasses and rating period were not significant. This meant that the slope of von Zerssen scores did not change significantly when color of glasses changed or due to the interaction of color of glasses and rating period.

Researchers hypothesized that the PSQI rating would improve if individuals were in the amber glasses condition and wearing the glasses, and that it would remain stable if they were in the blue condition. Internal reliability tests for the PSQI showed a Cronbach's alpha of .636 overall. The mixed model analysis used whether individuals wore glasses or not (rating period), color of glasses, and the interaction of rating period and color of glasses as predictors, and PSQI (POMP) scores as the outcome variable. The intercept ($b_0 = .39, p < .01$) and whether or not the individuals were wearing glasses ($b_1 = -.11, p < .01$) were both significant. This meant that the intercept for PSQI (POMP) scores was significantly different than zero if someone was not in the amber lenses group and was not wearing glasses, and that the slope of the scores on the PSQI differed significantly when individuals wore glasses as opposed to when they did not wear glasses. The color of glasses and the interaction between color of glasses and rating period were not significant, which meant that the slope of PSQI (POMP) Scores did not differ significantly when these variables changed.

Finally, the researchers had hypothesized that sleep quality and energy ratings (as rated on a daily basis in the sleep diary) would improve for those individuals in the amber lenses condition if they were wearing the glasses, and they would remain the same for individuals in the control, or blue glasses, group. A fifth mixed model analysis looked at rating period, glasses color, and interaction of rating period and glasses color as the predictors, and sleep quality as scored on the sleep diary as outcome variables. The intercept was significant ($b_0 = 3.45, p < .01$), but none of the other slopes of the model were significant. This meant that if the individual was not wearing glasses and was in the blue condition, then the intercept was significantly different than 0, but it also meant that there was no significant change in slope due to the glasses color, the rating period, or the interaction of the two.

The final mixed model analysis tested whether energy ratings on the sleep diaries changed significantly as a result of glasses color, rating period, and the interaction of glasses color and rating period. The model had a significant intercept ($b_0 = 3.52, p < .01$), but none of the other values were significant. This meant that the intercept was significantly different than zero if the individual was not in the experimental condition and was not wearing the glasses. However, the rating period, glasses color, and the interaction of the two did not impact the slope of energy scores as rated on the sleep diary.

Discussion

Researchers had hypothesized that the amber glasses group would see significant improvements in somatic complaints (von Zerssen), sleep quality (PSQI and Sleep Diary Ratings), Energy (Sleep Diary Ratings) and Positive Affect scores (indicating higher levels of PA), and a significant decrease in Negative Affect scores (indicating lower levels of NA) for the rating periods when wearing glasses. We did not expect individuals in the blue glasses condition to see improvement from their baseline to their experimental ratings. In order for these hypotheses to be supported, the interaction effects in the mixed models would have had to be significant. Because none of the interaction effects were significant, we can conclude that these hypotheses were not supported.

These results appear to run contrary to what the literature has found so far (Burkhart & Phelps, 2009; Kayumov et al., 2005; Sasseville et al., 2006), but there are a number of reasons why this could be occurring. One possibility is that participants expected to see a change and this influenced the way in which they filled out the self-report measures (Parsons, 1974). Individual confounds may also not be equally distributed between the groups (i.e., randomization failure). The research was conducted at a busy time of the semester, and exams, papers, and other stresses

may have played into how individuals filled out the self-report measures. Because participants were not randomized according to these factors, these factors may not have been equally distributed between the 2 groups. Randomization assures that these unmeasured factors tend to be balanced between groups, but it is still possible for random assignment to include more of a particular factor in one group by chance. Historical events also occurred on campus while the study was being conducted, including a triple homicide (Grubb, 2015), which may have impacted ratings of positive and negative affect.

Another possibility is that the blue glasses are also having a physiological impact, and thus are also influencing the outcome measures. With the exception of Positive Affect, and the sleep diary ratings, wearing the glasses regardless of lens color had a significant effect on all participants. This may indicate that the blue glasses are having an impact as well as the amber glasses, either due to expectancy (“Hawthorne”) effects, or physiological activity. There also may be basic biological differences, leading to individuals who respond to the glasses, and individuals who do not, perhaps as a result of genetic polymorphisms (Burkhart & Phelps, 2009). If enough individuals are in a group who are not responsive to the glasses treatment, then effects would be hard to see.

Furthermore, college students often alter their schedules to fit social and academic constraints without much problem, despite any biological predispositions (Thun et al., 2012). As one affected participant in the amber glasses condition put it during the debriefing, the glasses made it difficult to study into the early hours of the morning as they were used to doing. Another participant in the amber glasses condition said they had to force themselves to stay awake to study, but they also started waking up at 6 a.m. Both of these responses indicate that even with biological responses, it is sometimes inconvenient for college students to listen to the biological

signals, so they simply do not. Individuals may have known about the hypothesis, or guessed over time, although the answers given during the consent process and debriefing showed few indications of this. All of these could have contributed to the variety of responses to the self-report measures that led to non-significant results.

Limitations include some of the aforementioned factors, such as control glasses color and timing. The population was overwhelmingly female, and a more varied sample, racially and in gender distribution, could be very valuable. Circadian processes also fluctuate along with the menstrual cycle in women (Portaluppi, Touitou, & Smolensky, 2008), potentially adding to the heterogeneity of responses among female participants. Researchers also did not exclude anyone, with the rationale that in a real world situation, the glasses would hopefully impact anyone, regardless of their current life situation.

These possibilities and limitations raise the question of whether these glasses are effective in all populations. They may work better with working adult populations who have more regular sleep and work schedules, individuals who are motivated to see a change in their sleep schedules, and individuals who have a biological predisposition to be impacted by blue light. Because of this, it is still a line of research worth pursuing. The impact may be much greater in other populations than in college students during the middle of a difficult semester. However, if the effects can be over-ridden by lifestyle factors or stressful experiences, it suggests that the effects may also be more limited in clinical applications such as the treatment of bipolar disorder (cf. Henriksen et al., 2014).

It would be valuable to explore the impact of the glasses in different populations, including clinical populations. Using a third glasses color would increase an understanding of the impact of blue glasses on mood or sleep. Experiments that utilize different scales for sleep

quality and mood would add variety and help identify measures that work well in studies seeking to combine sleep research with psychological studies. Further studies that collect data with more objective measures, such as melatonin samples and other biomarkers (e.g., Sasseville et al., 2006), or use actimetry as a way of measuring sleep and activity (e.g., Thun et al., 2012), would build strength and validity of results.

In conclusion, though the study did not yield expected results, this does not rule out the possibility that amber glasses could be an effective way to improve sleep quality and mood. Careful attention to detail, research with a variety of populations, and improvement of measures and methods have the potential to lead to entirely different conclusions. Identifying those specific areas would be valuable, because it would give researchers and clinicians a much clearer idea of areas in the field where amber lenses would be of the most use.

References

- American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Washington, DC: Author.
- Barbini, B., Benedetti, F., Colombo, C., Dotoli, D., Bernasconi, A., Cigala-Fulgosi, M., . . . Smeraldi, E. (2005). Dark therapy for mania: a pilot study. *Bipolar Disorders*, 7(1), 98-101. doi: 10.1111/j.1399-5618.2004.00166.x
- Barion, A. (2011). Circadian rhythm sleep disorders. *Disease A Month*, 57(8), 423-437. doi: 10.1016/j.disamonth.2011.06.003
- Bolger, N., & Laurenceau, J. P. (2013). *Intensive longitudinal methods: An introduction to diary and experience sampling research*. New York, N.Y.: Guilford Press.

- Burkhart, K., & Phelps, J. R. (2009). Amber lenses to block blue light and improve sleep: a randomized trial. *Chronobiology International*, 26(8), 1602-1612. doi: 10.3109/07420520903523719
- Buyse, D. J., Reynolds, C. F., 3rd, Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Research*, 28(2), 193-213. doi: [10.1016/0165-1781\(89\)90047-4](https://doi.org/10.1016/0165-1781(89)90047-4)
- Cohen, P., Cohen, J., Aiken, L. S., & West, S. G. (1999). The problem of units and the circumstances for POMP. *Multivariate Behavioral Research*, 34, 315-346. doi: [10.1207/s15327906mbr3403_2](https://doi.org/10.1207/s15327906mbr3403_2)
- Emens, J., Lewy, A., Kinzie, J. M., Arntz, D., & Rough, J. (2009). Circadian misalignment in major depressive disorder. *Psychiatry Research*, 168(3), 259-261. doi: 10.1016/j.psychres.2009.04.009
- Even, C., Schroder, C. M., Friedman, S., & Rouillon, F. (2008). Efficacy of light therapy in nonseasonal depression: a systematic review. *Journal of Affective Disorders*, 108(1-2), 11-23. doi: 10.1016/j.jad.2007.09.008
- Golden, R. N., Gaynes, B. N., Ekstrom, R. D., Hamer, R. M., Jacobsen, F. M., Suppes, T., . . . Nemeroff, C. B. (2005). The efficacy of light therapy in the treatment of mood disorders: a review and meta-analysis of the evidence. *American Journal of Psychiatry*, 162(4), 656-662. doi: 10.1176/appi.ajp.162.4.656
- Grubb, Tammy. (2015, February 10). Chapel Hill police arrest man in triple homicide. *The News and Observer*. Retrieved from www.newsobserver.com

- Harvey, A. G., Murray, G., Chandler, R. A., & Soehner, A. (2011). Sleep disturbance as transdiagnostic: consideration of neurobiological mechanisms. *Clinical Psychology Review*, 31(2), 225-235. doi: 10.1016/j.cpr.2010.04.003
- Henriksen, T. E., Skrede, S., Fasmer, O. B., Hamre, B., Gronli, J., & Lund, A. (2014). Blocking blue light during mania - markedly increased regularity of sleep and rapid improvement of symptoms: a case report. *Bipolar Disorders*. doi: 10.1111/bdi.12265
- Kaplan, K. A., & Harvey, A. G. (2009). Hypersomnia across mood disorders: a review and synthesis. *Sleep Medicine Reviews*, 13(4), 275-285. doi: 10.1016/j.smrv.2008.09.001
- Kayumov, L., Casper, R. F., Hawa, R. J., Perelman, B., Chung, S. A., Sokalsky, S., & Shapiro, C. M. (2005). Blocking low-wavelength light prevents nocturnal melatonin suppression with no adverse effect on performance during simulated shift work. *Journal of Clinical Endocrinology & Metabolism* 90(5), 2755-2761. doi: 10.1210/jc.2004-2062
- Kennaway, D. J., Moyer, R. W., Voultsios, A., & Varcoe, T. J. (2001). Serotonin, excitatory amino acids and the photic control of melatonin rhythms and SCN c-FOS in the rat. *Brain Research*, 897(1-2), 36-43. doi: [10.1016/S0006-8993\(01\)02091-1](https://doi.org/10.1016/S0006-8993(01)02091-1)
- Košćec, A., Radošević-Vidaček, B., & Kostović, M. (2001). Morningness–eveningness across two student generations: would two decades make a difference? *Personality and Individual Differences*, 31(4), 627-638. doi: [http://dx.doi.org/10.1016/S0191-8869\(00\)00167-7](http://dx.doi.org/10.1016/S0191-8869(00)00167-7)
- Lavoie, M. P., Lam, R. W., Bouchard, G., Sasseville, A., Charron, M. C., Gagne, A. M., . . . Hebert, M. (2009). Evidence of a biological effect of light therapy on the retina of patients with seasonal affective disorder. *Biological Psychiatry*, 66(3), 253-258. doi: 10.1016/j.biopsych.2008.11.020

- Lockley, S. W., Brainard, G. C., & Czeisler, C. A. (2003). High sensitivity of the human circadian melatonin rhythm to resetting by short wavelength light. *Journal of Clinical Endocrinology and Metabolism*, 88(9), 4502-4505. doi: 10.1210/jc.2003-030570
- McClung, C. A. (2011). Circadian rhythms and mood regulation: insights from pre-clinical models. *European Neuropsychopharmacology*, 21 Suppl 4, S683-693. doi: 10.1016/j.euroneuro.2011.07.008
- Monk, T. H., Buysse, D. J., Reynolds, C. F., 3rd, Jarrett, D. B., & Kupfer, D. J. (1992). Rhythmic vs homeostatic influences on mood, activation, and performance in young and old men. *Journals of Gerontology*, 47(4), P221-227. doi: [10.1093/geronj/47.4.p221](https://doi.org/10.1093/geronj/47.4.p221) .
- Parsons, H. M. (1974). What Happened at Hawthorne?: New evidence suggests the Hawthorne effect resulted from operant reinforcement contingencies. *Science*, 183(4128), 922-932. doi: 10.1126/science.183.4128.922
- Portaluppi, F., Touitou, Y., & Smolensky, M. H. (2008). Ethical and methodological standards for laboratory and medical biological rhythm research. *Chronobiology International*, 25(6), 999-1016. doi: 10.1080/07420520802544530
- Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models: Applications and data analysis methods* (2nd ed.). Newbury Park, CA: Sage.
- Roybal, K., Theobald, D., Graham, A., DiNieri, J. A., Russo, S. J., Krishnan, V., . . . McClung, C. A. (2007). Mania-like behavior induced by disruption of CLOCK. *Proceedings of the National Academy of Sciences USA*, 104(15), 6406-6411. doi: 10.1073/pnas.0609625104
- Sasseville, A., Paquet, N., Seignin, J., & Hebert, M. (2006). Blue blocker glasses impede the capacity of bright light to suppress melatonin production. *Journal of Pineal Research*, 41(1), 73-78. doi: 10.1111/j.1600-079X.2006.00332.x

Thun, E., Hilde Nordhus, I., Utnes, I., Halvor Lilleholt, T., Johansen, T., Sivertsen, B., . . .

Pallesen, S. (2012). An Actigraphic Validation Study of Seven Morningness-Eveningness Inventories. *European Psychologist*, 17(3), 222-230. doi: 10.1027/1016-9040/a000097

Van Mill, J. G., Hoogendijk, W. J., Vogelzangs, N., van Dyck, R., & Penninx, B. W. (2010).

Insomnia and sleep duration in a large cohort of patients with major depressive disorder and anxiety disorders. *Journal of Clinical Psychiatry*, 71(3). doi:

10.4088/JCP.09m05218gry

von Zerssen, D. (1975). *Die beschwerden-liste. Parallelförmigen B-L und B-L'. Ergänzungsbogen B-L*. Beltz: Weinheim.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, 54(6), 1063-1070. doi: [10.1037//0022-3514.54.6.1063](https://doi.org/10.1037//0022-3514.54.6.1063)

Yan, L., Bobula, J. M., Svenningsson, P., Greengard, P., & Silver, R. (2006). DARPP-32 involvement in the photic pathway of the circadian system. *The Journal of Neuroscience*, 26(37), 9434-9438. doi: 10.1523/JNEUROSCI.2538-06.2006

Yoo, S. S., Gujar, N., Hu, P., Jolesz, F. A., & Walker, M. P. (2007). The human emotional brain without sleep--a prefrontal amygdala disconnect. *Current Biology*, 17(20), R877-878. doi: 10.1016/j.cub.2007.08.007

Youngstrom, E. A. (2014, December). *Preliminary test of amber glasses as a way of resetting circadian melatonin release: Randomized trial during travel from Asia*. Paper presented at the Annual meeting of the American College of Neuropsychopharmacology, Phoenix, AZ.

Zelinski, E. L., Deibel, S. H., & McDonald, R. J. (2014). The trouble with circadian clock dysfunction: multiple deleterious effects on the brain and body. *Neuroscience & Biobehavioral Review*, 40, 80-101. doi: 10.1016/j.neubiorev.2014.01.007

Zohar, D., Tzischinsky, O., Epstein, R., & Lavie, P. (2005). The effects of sleep loss on medical residents' emotional reactions to work events: a cognitive-energy model. *Sleep*, 28(1), 47-54.

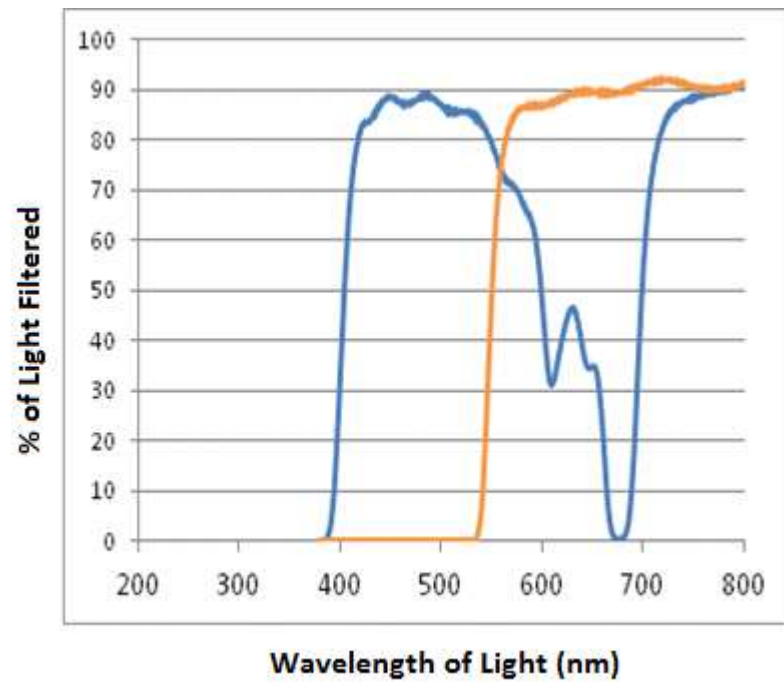


Figure 1. Light transmittance rate for blue and amber lenses. Peak wavelength of melatonin suppression is ~446-477 nm.

Table 1

Distribution of Gender, Age, Year in School (Overall and By Condition)

	Male	Female	Age (<i>M</i>)	Age (<i>SD</i>)	Year in School (<i>M</i>)	Year in School (<i>SD</i>)
Blue	3	10	19.62	1.12	2.54	1.27
Amber	3	11	19.65	2.34	2.21	2.26
Overall	6	21	19.62	1.82	2.37	1.82

Table 2

Distribution of ethnicity

Ethnicity	Count	Proportion
Caucasian	15	.56
African American	2	.07
Asian American	7	.26
Hispanic	3	.11

Table 3

Descriptive Statistics of PANAS, VZ, Energy, and Sleep Quality

	<i>N</i>	Mean	<i>SD</i>	Min	Max
Positive Affect (POMP)	475	.37	.23	0	1
Negative Affect (POMP)	475	.10	.12	0	.75
Von Zerssen	474	176.62	.70	54	188
Sleep Quality (Diary)	456	3.54	.94	0	5
Energy (Diary)	457	3.56	.93	0	5

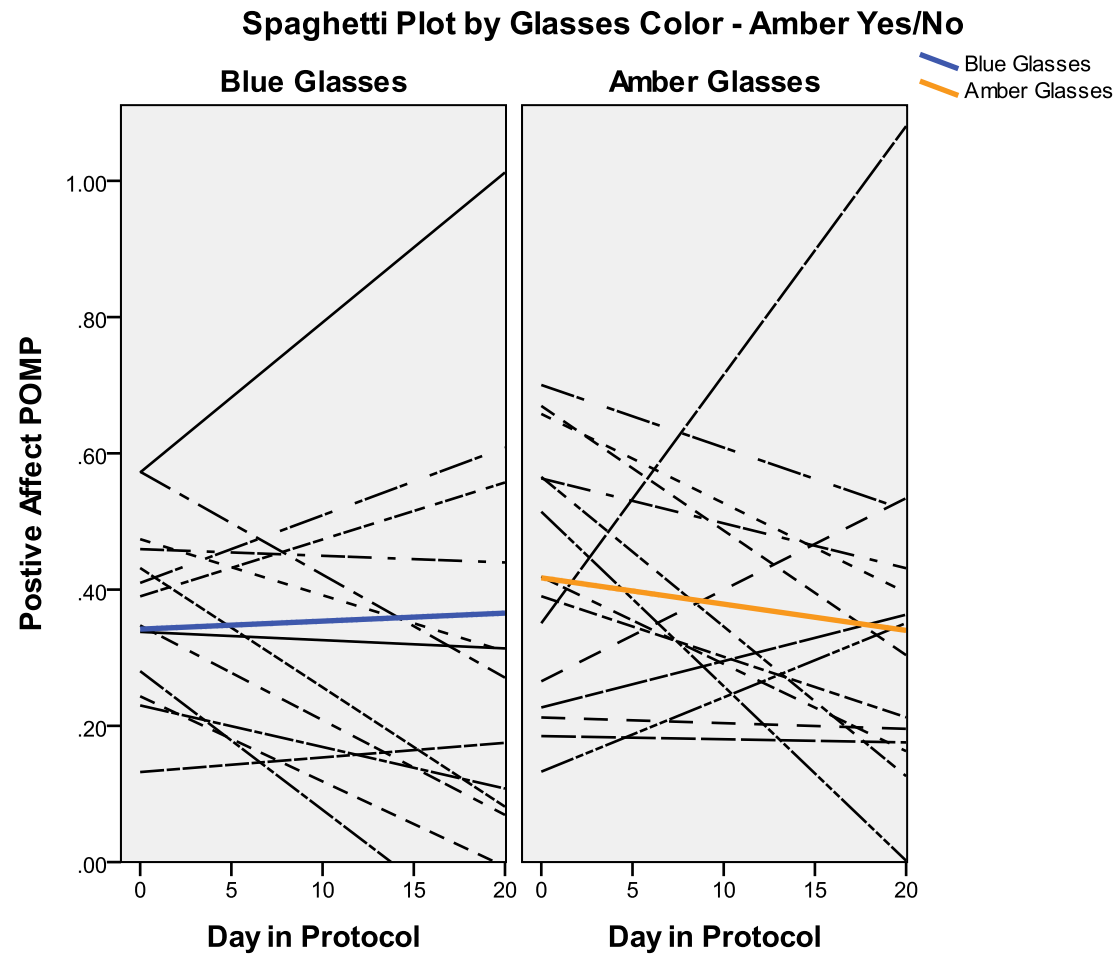


Figure 2. Spaghetti plot of linear trends within person for Positive Affect, split by glasses color.

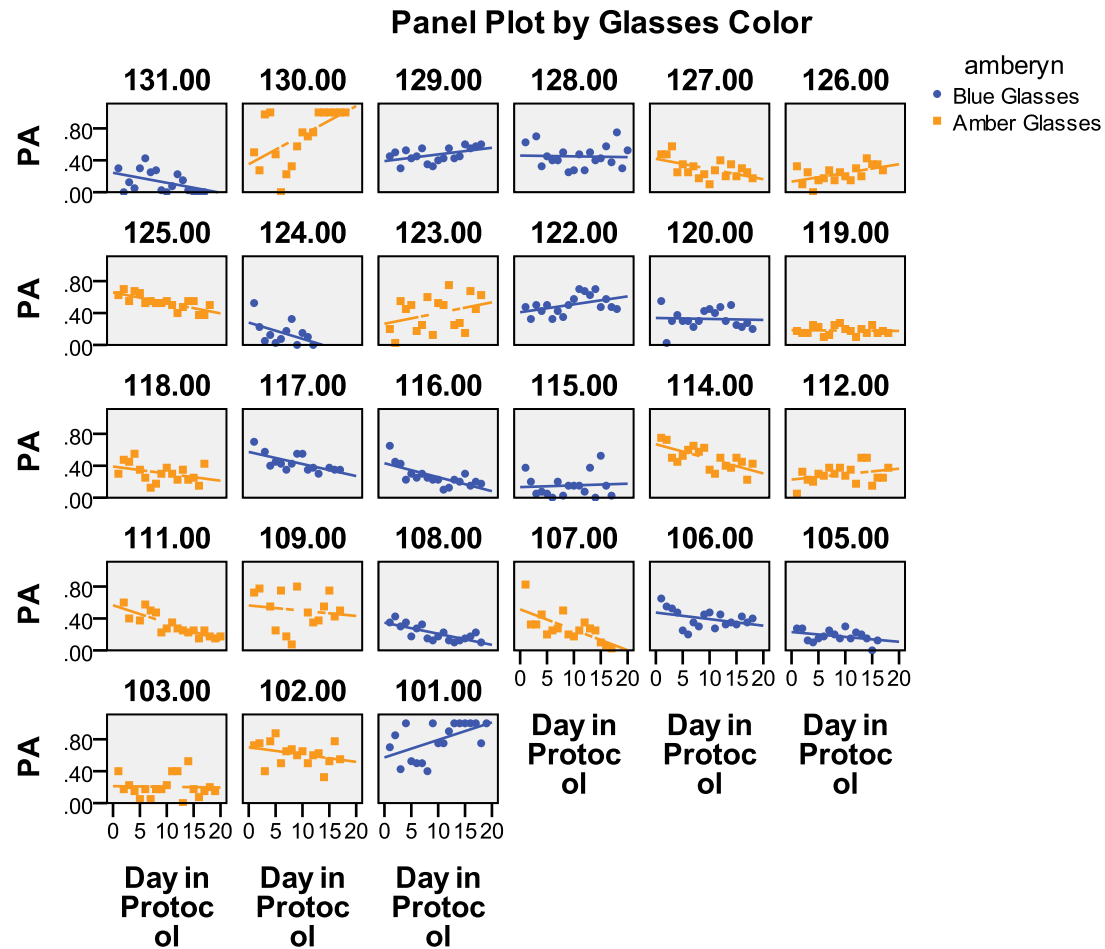


Figure 3. Panel plot of individual data for Positive Affect.

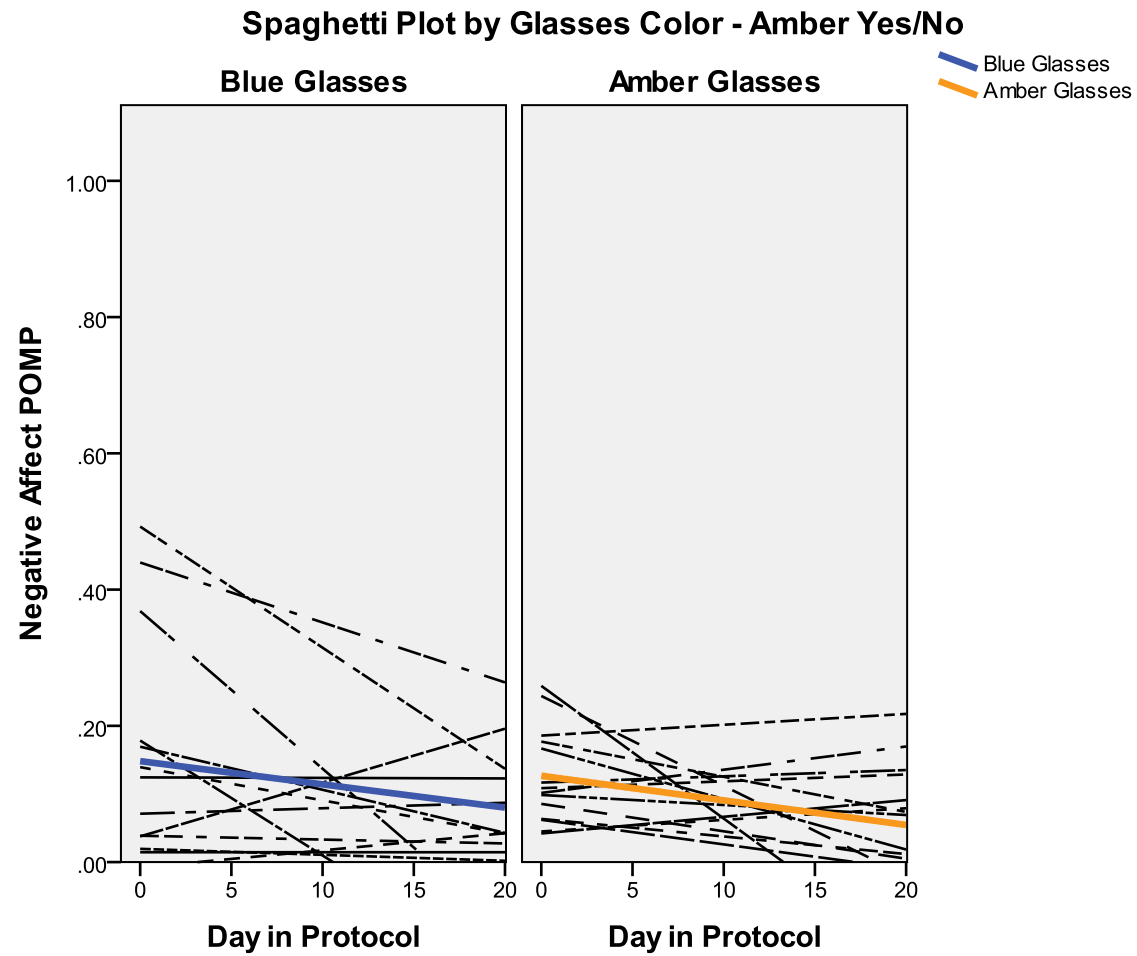


Figure 4. Spaghetti plot of linear trends within person for Negative Affect (POMP), split by glasses color.

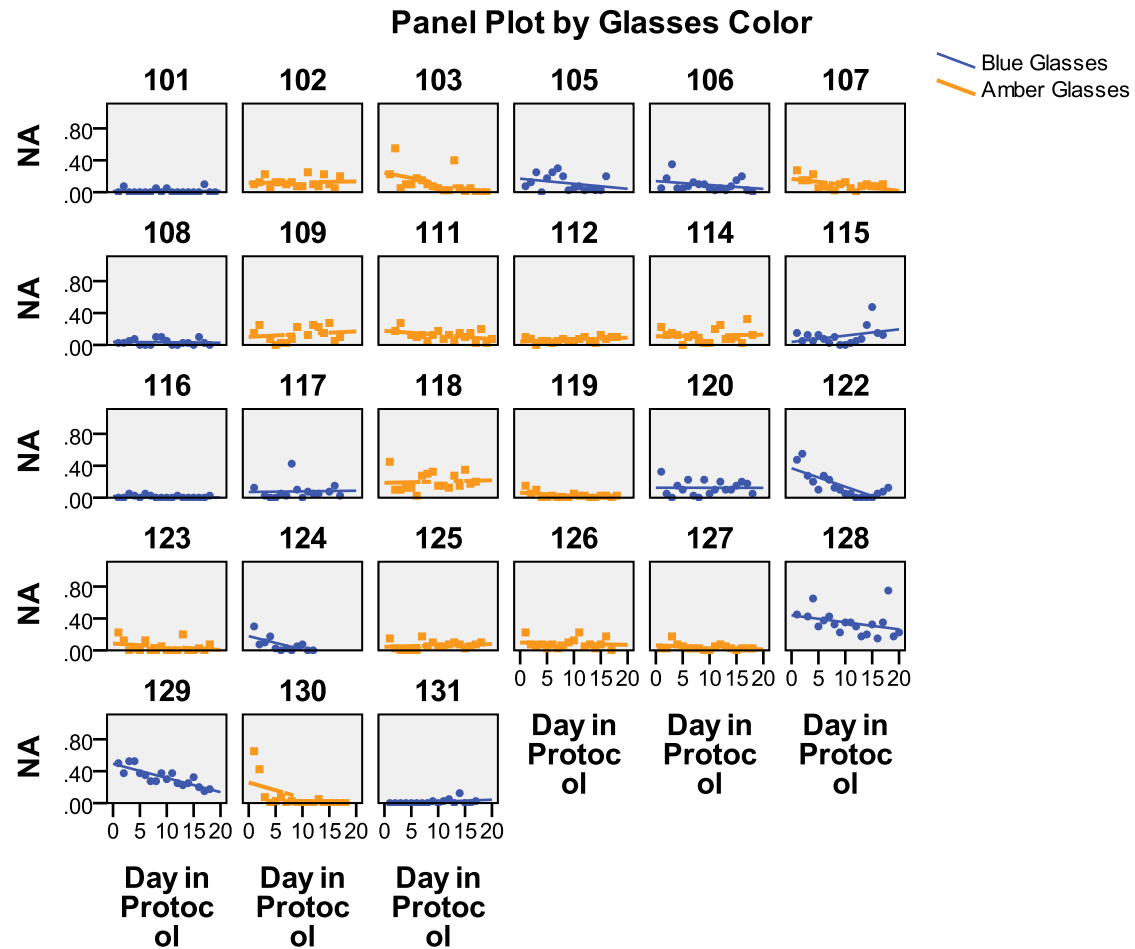


Figure 5. Panel plot of individual data for Negative Affect.

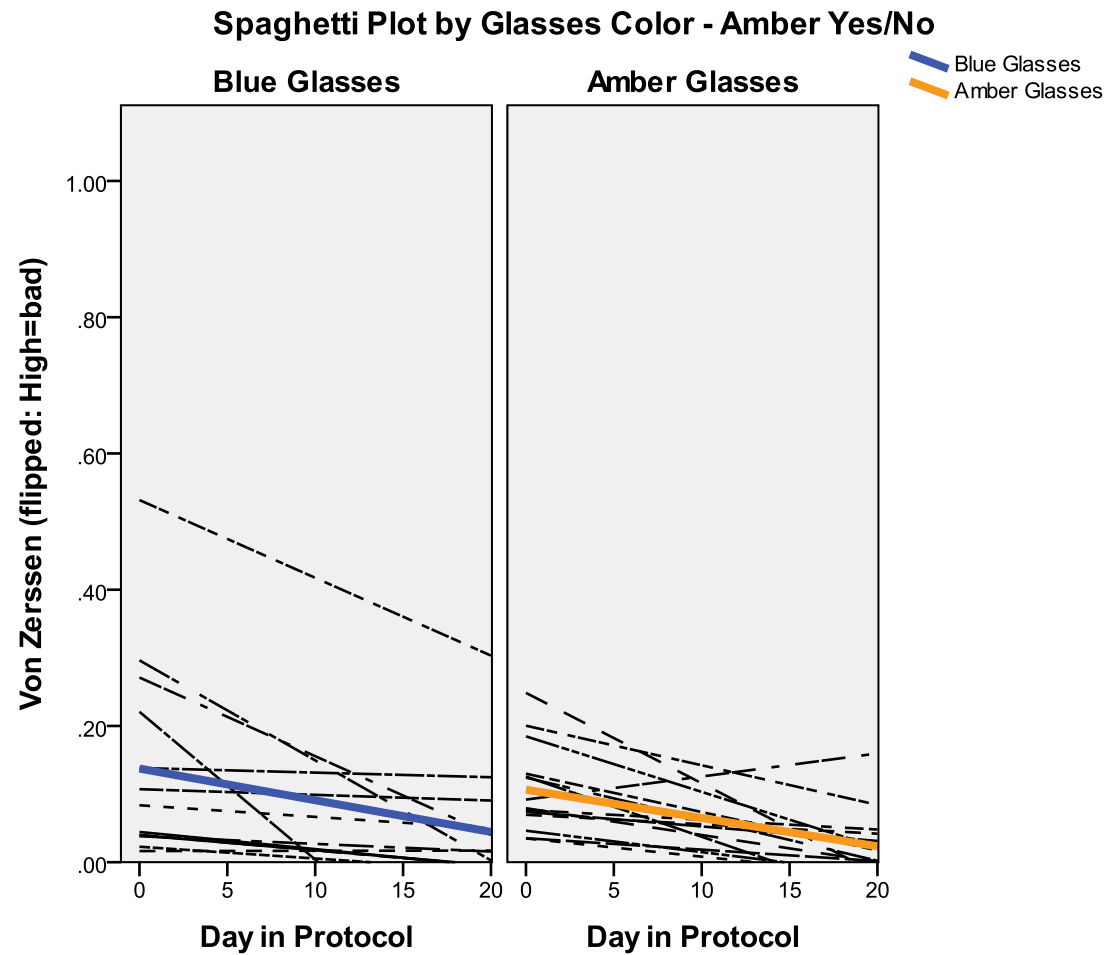


Figure 6. Spaghetti plot of linear trends within person for von Zerssen (flipped so that high score indicates more complaints) split by glasses color.

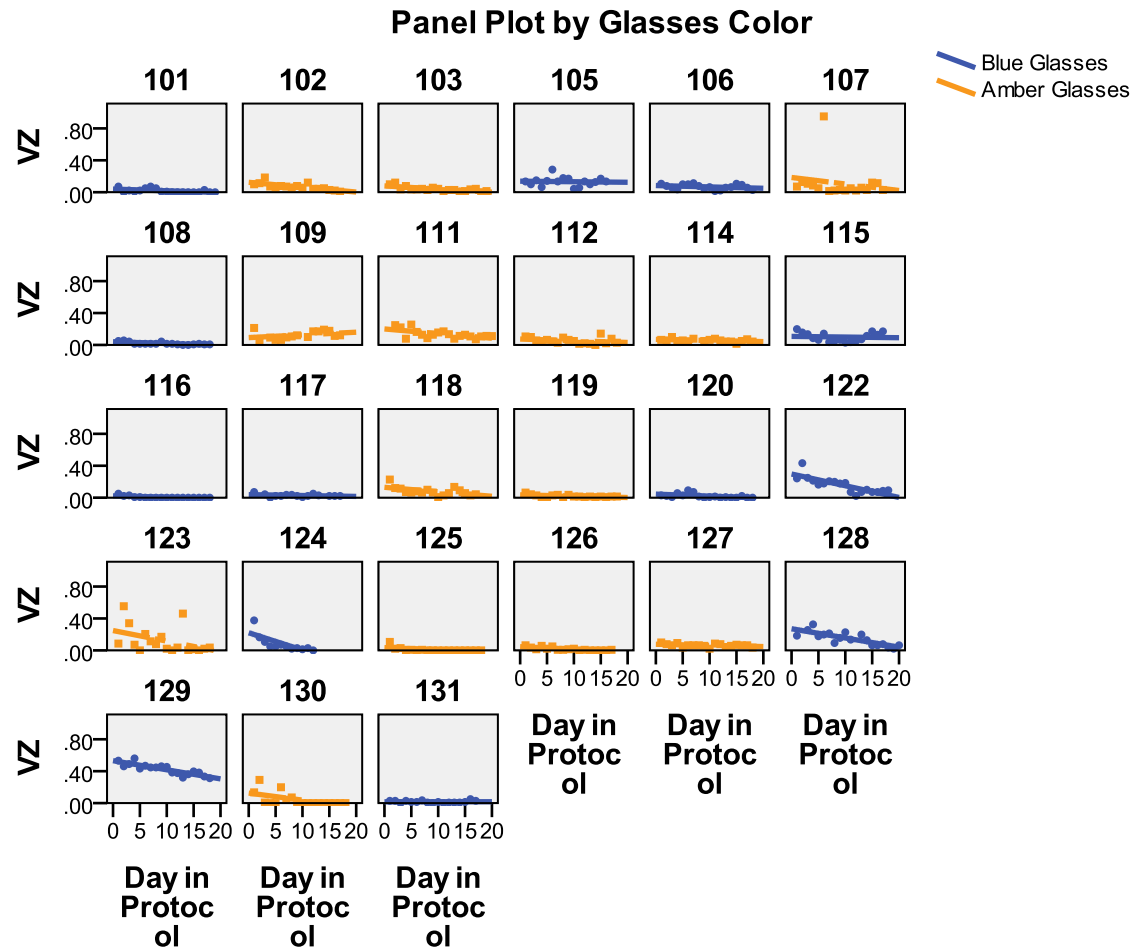


Figure 7. Panel plot of individual data for von Zerssen Complaints (flipped so that high score indicates more complaints).

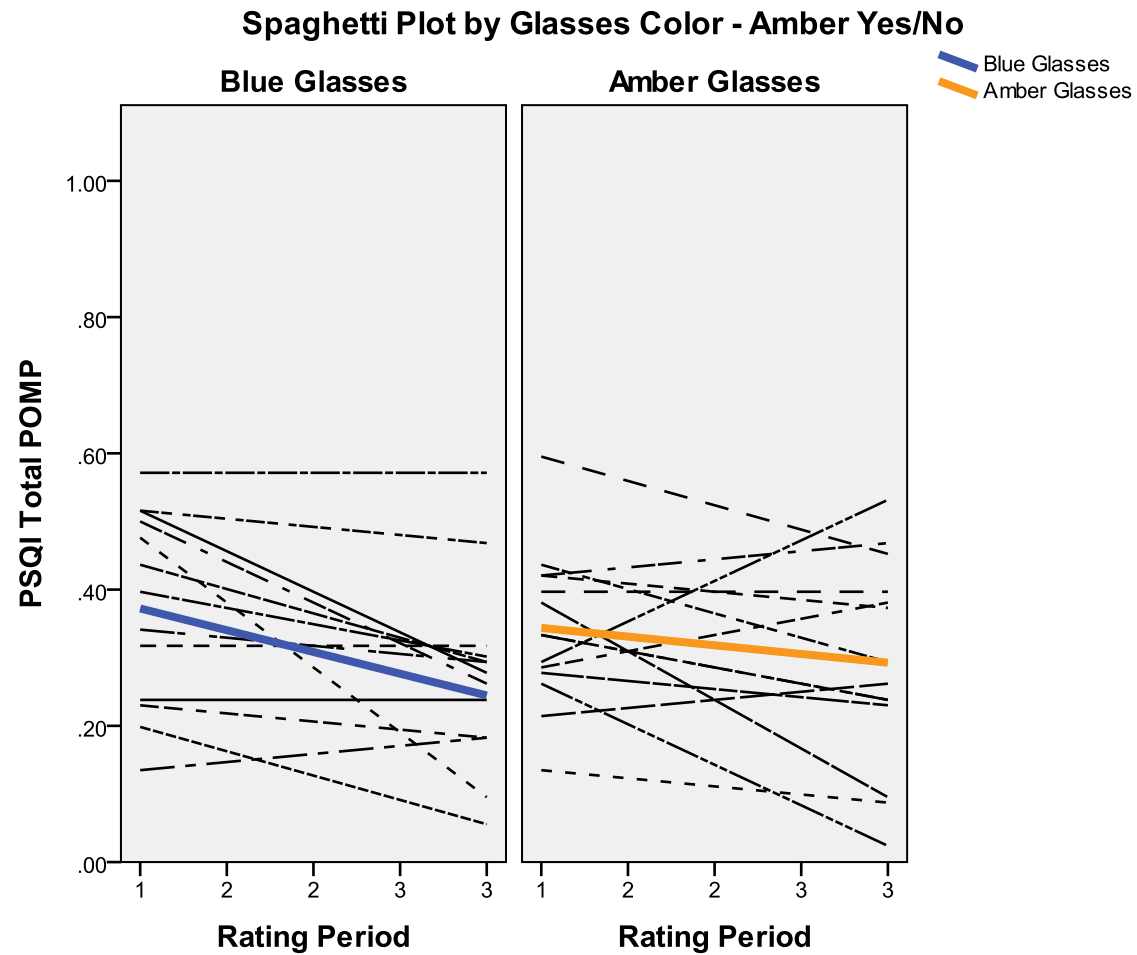


Figure 8. Spaghetti plot of linear trends within person for PSQI Totals (POMP) split by glasses color (collected every six days).

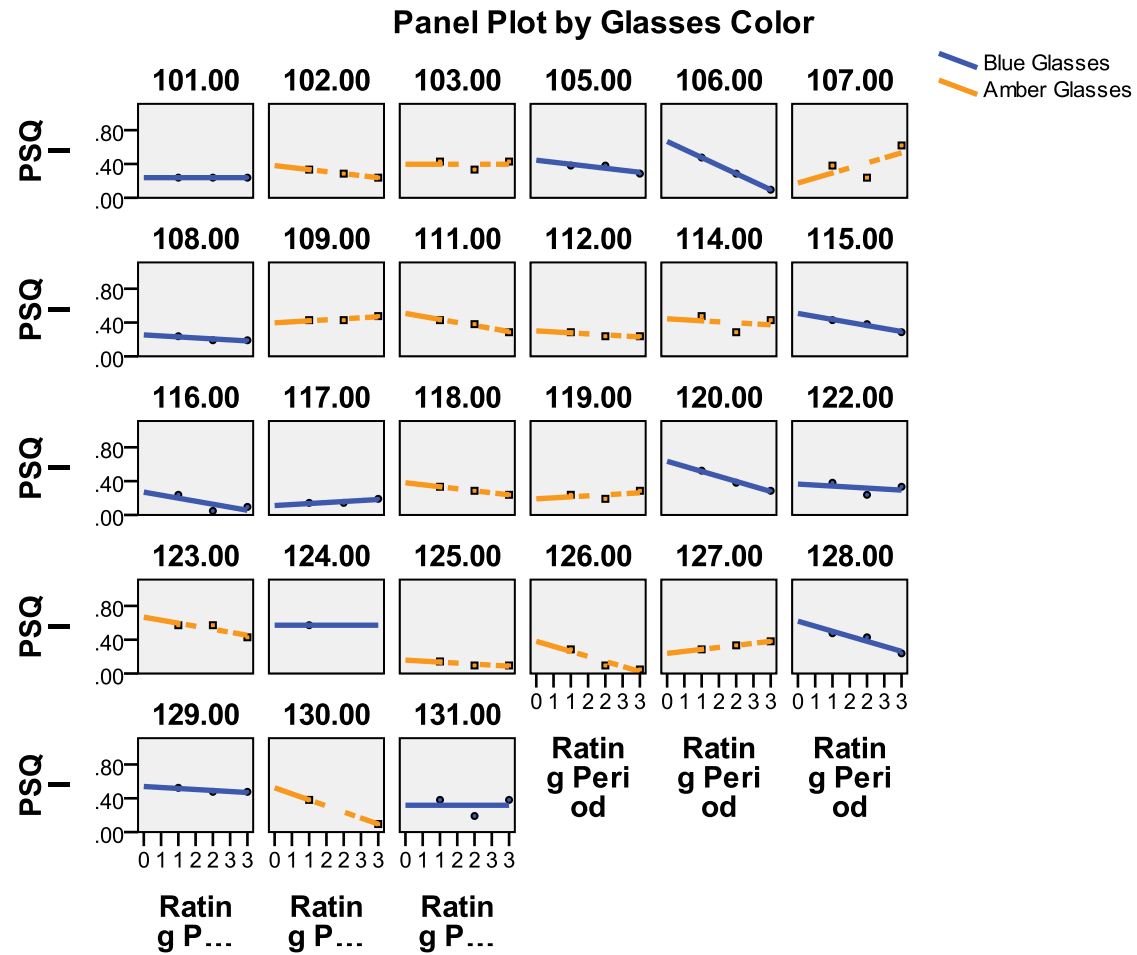


Figure 9. Panel plot of individual data for PSQI Total POMP.

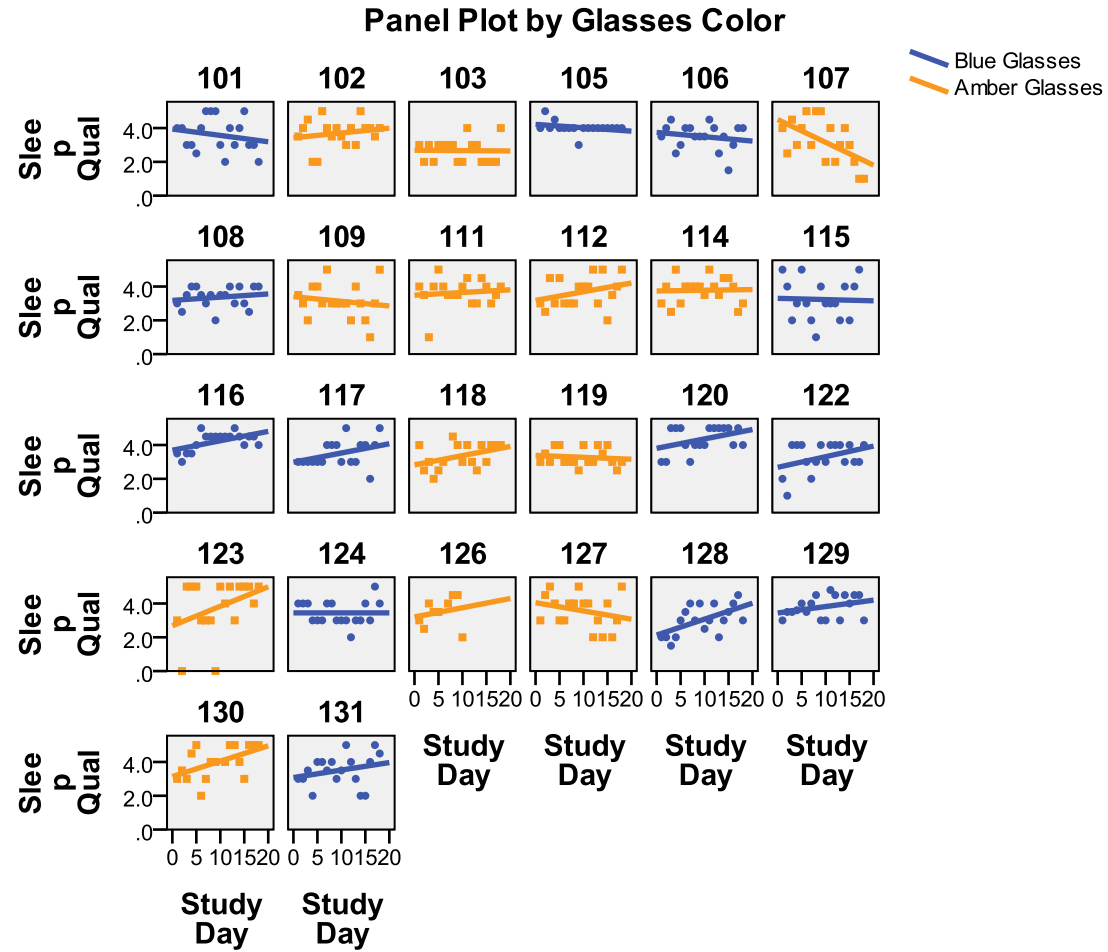


Figure 10. Panel plot of individual data for Sleep Quality (Sleep Diary).

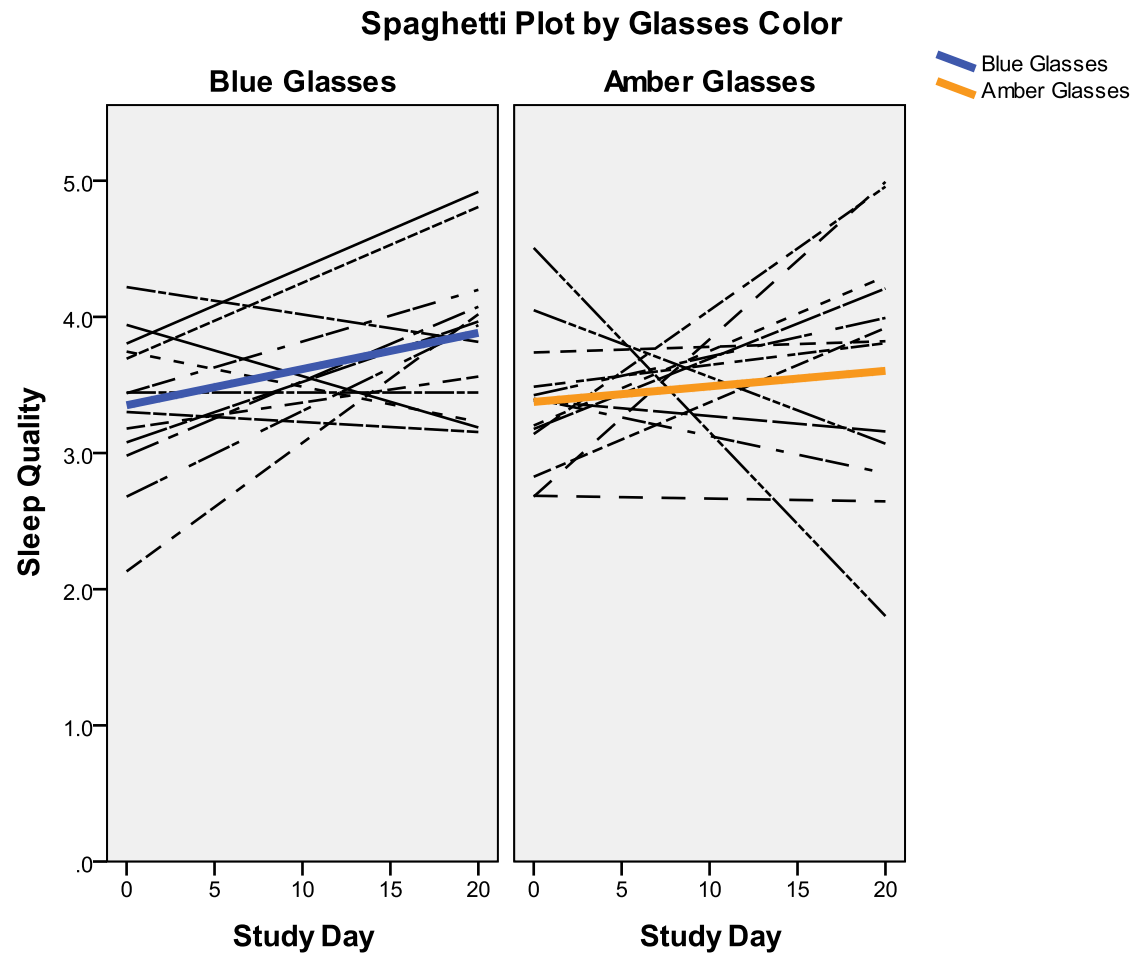


Figure 11. Spaghetti plot of linear trends within person for Sleep Quality (Sleep Diary), split by glasses color.

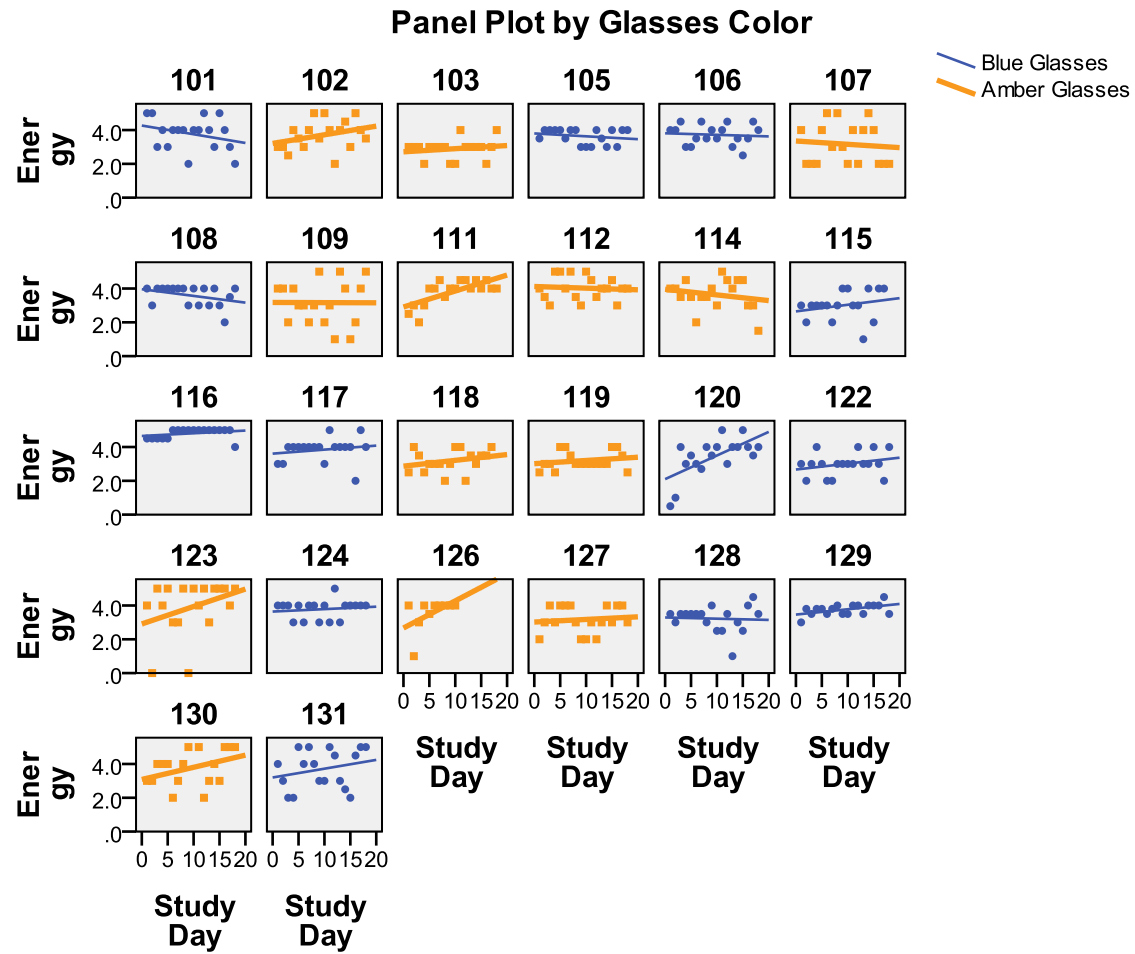


Figure 12. Panel plot of individual data for Energy (Sleep Diary).

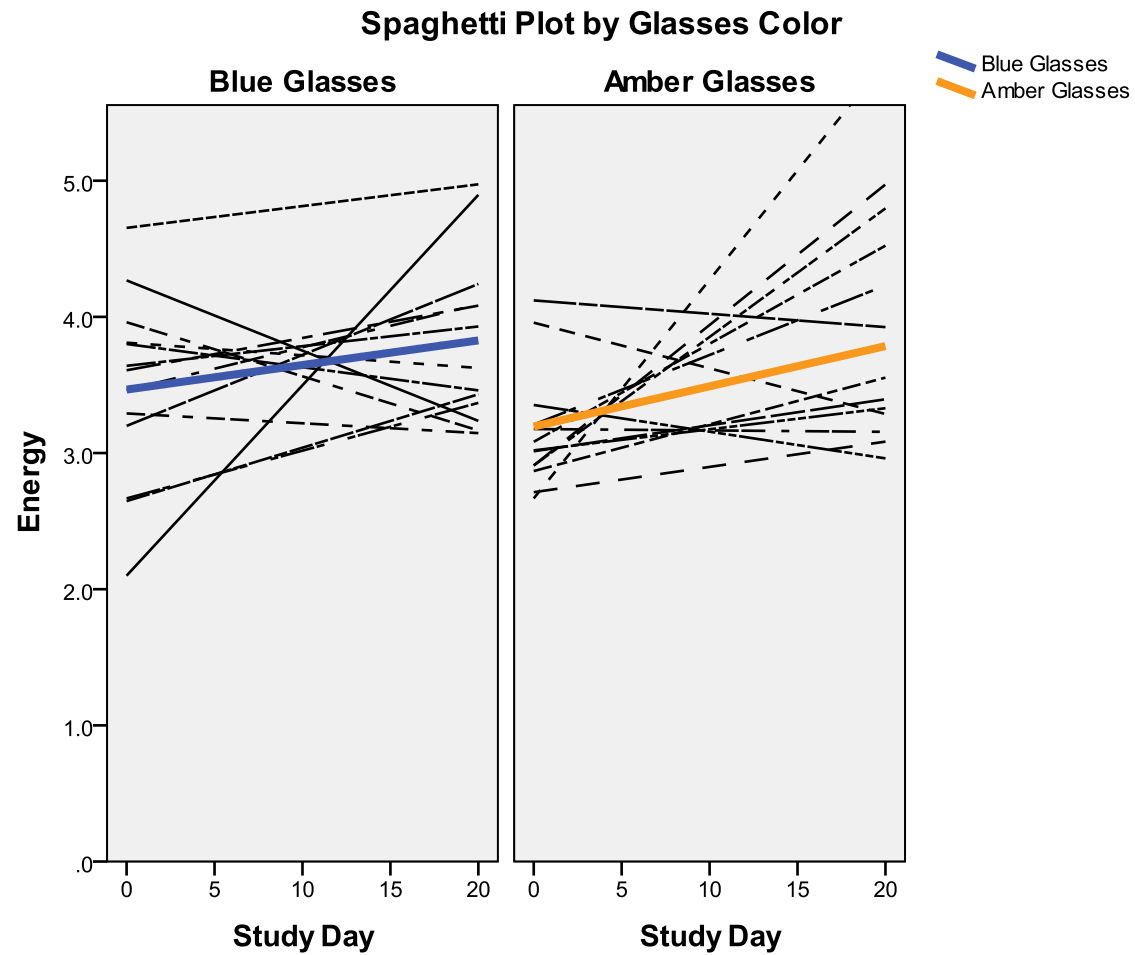


Figure 13. Spaghetti plot of linear trends within person for Energy (Sleep Diary), split by glasses color.